a larger share in all works undertaken to promote the welfare of their country.

The author does not claim to be a botanist, nor does Dr. Schlich, who preceded Mr. Ribbentrop, nor does their successor, Mr H. C. Hill, the present Inspector-General of Forests. It is necessary to mention this because in England, also among scientific men, the opinion prevails that forestry is a branch of botany, and that a forester who is not a botanist cannot claim to be a scientific man. Dr. Schlich's great merit while holding the appointment in India was to organise that branch of forestry which deals with the plans regulating the working of the forests, a business which is based more upon mathematics than upon botany. Mr. Ribbentrop's great achievement has been to study and correctly to appreciate the peculiar sylvicultural requirements of the great variety of trees and bamboos with which the forester has to deal in India. Through his labours the management of teak, of sal, sissoo, deodar, and of other important trees when growing by themselves or in company with other kinds or with bamboos, their regeneration, natural or artificial, and their subsequent treatment under different conditions of soil and climate, is much better understood now than it was twenty years ago. These are great results, which, provided no retrograde measures are adopted, will bear fruit in steadily increasing the productive powers and capital value of the forests, and will contribute largely to the welfare of the millions inhabiting the British Indian Empire.

DIETRICH BRANDIS.

SUBMARINE BOATS.

THE building of five submarine boats for the British Navy not only forms quite a new departure but also, perhaps, the advent of the nucleus for an instrument of war of novel design. The boats (says *Engineering*, March 29), which are being built by Messrs. Vickers, Sons and Maxim, Ltd., are of the *Holland* improved type and are 63 ft. 4 in. in length over all, 11 ft. 9 in. beam, and 120 tons displacement submerged, and they will be capable of expelling torpedoes either with the boat at rest, during the run on the surface, or steaming at any speed submerged. When running on the surface the boats will be propelled by a gasoline engine (of marine type, inverted, and with four single acting cylinders). The amount of fuel carried will suffice for a run of about 400 miles with a maximum speed of about 9 knots, and when submerged an electric motor of the waterproof type, worked with storage batteries, will give the vessel a speed of seven knots, which can be maintained for four hours. The general operation of the boat is given as follows:—"Before it is desired to make a dive, the boat is brought to 'awash' condition, with only the conning tower ports above the water. The dive is then made at a small angle until the proper depth is reached, when by automatic means the boat is brought to a horizontal position. After the discharge of the torpedo from the fixed bow tube, the compensation for the weight of the torpedo is made automatically, causing only a slight change of trim for a few seconds. Provision is made for quick rising and diving, the time of appearance of the conning tower above the water being dependent on the skill of the navigator." In the United States Navy the *Holland* has undergone most exacting trials and has proved herself "stable in service working," and it is here we get the most convincing testimony, where Admiral Hitchborn, chief constructor in the United States Navy, states in his official report, "The *Holland* has shown herself capable of such complete control in the vertical plane that she may be kept within a few inches of any desired depth while moving, or brought to the surface and taken under again in a very short time: her direction and control in the horizontal plane on the surface is effected with the same facility as any other craft, and submerged is limited only by the difficulties of vision: her crew are provided for on board with reasonable comfort and perfect safety for such periods as she may be in service and working either upon the surface or submerged; and her armament, consisting entirely of torpedoes, gives her great offensive power."

THE CURRENTS IN THE GULF OF ST. LAWRENCE.

IN a former article (January 24, 1901, p. 311) we gave a summary, from a pamphlet recently issued, on the currents in the Gulf of St. Lawrence, in which we noticed some points of general application to similar researches elsewhere. This pamphlet, issued by the Department of Marine and Fisheries, Canada, gives concisely the results of investigations in th summer seasons of three years in that Gulf, conducted by Mr. W. Bell Dawson, in charge of the Survey of Tides and Currents. It is primarily for the benefit of practical seamen; but it also contains an explanation of the hydrography of the Gulf, on which this Survey has thrown considerable light; and it is this part that we now summarise.

General Characteristics of the Gulf of St. Lawrence.—With the exception of the currents in the various straits and near the heads of the bays, the currents met with in the open Gulf seldom exceed one knot. They are, therefore, the more easily influenced by strong winds, especially at the surface of the water. Currents which have a greater speed than this are found in Belle Isle and Cabot Straits, in Northumberland Strait, off the Gapsé coast, in the Gut of Canso, and locally in channels between islands and at the mouths of rivers.

The water of the Gulf may be roughly divided by a line running from South-west Point of Anticosti to the middle of Cabot Strait. Along the south-western side of this line the water has a lower density, as it is apparently made a little fresher by the outflow of the St. Lawrence River. To the north-east of this line, throughout the north-eastern arm of the Gulf, the water has the same density as in the open Atlantic.

The general drift of this water of lower density is outward, towards the Atlantic. This gives rise to two constant currents, one at the mouth of the St. Lawrence along the Gaspé coast, which may be called the "Gaspé Current," and the other on the west side of Cabot Strait around Cape North, which may be called the "Cape Breton Current." A third constant current is found on the west side of Newfoundland, making north-eastward from the Bay of Islands towards Rich Point.

It is to be noted that in calling these currents constant it is only meant that they usually or most frequently run in the one direction. During certain winds they may be much disturbed, or their direction may even be reversed.

Temperature.—It appears that in general the temperature of the surface water merely rises with the progress of the season; and it is also natural that the water should become warmer to a greater depth as the season advances. Even this has its limitations, however; as at a depth of 50 fathoms no greater rise in temperature has yet been found than from 32° to 34°, between the month of June and the end of September.

At all three angles of the Gulf it was found that the coldest water forms a layer between the depths of 30 and 50 fathoms. In the vicinity of Belle Isle Strait, the same low temperatures are also found at these depths; although there the temperature towards the surface is relatively lower, as a rule, than in other regions. It is probable that this cold layer extends very generally over the Gulf area. Below this cold layer, in the deep channel of the Gulf, the temperature from 100 to 200 fathoms is found to range very constantly from 38° to 41°. This result was obtained in Cabot Strait, and also between the Gaspé coast and Anticosti, 220 miles further in from the Atlantic, along the deep channel. This deep channel runs into the Gulf from the Atlantic basin through Cabot Strait, and maintains a continuous depth of some 200 fathoms across the middle of the Gulf to the mouth of the St. Lawrence River. It still has a depth of 100 fathoms half-way up the estuary on the Lower St. Lawrence.

Density.—It may be stated broadly that throughout the north-eastern portion of the Gulf the average surface density ranges from 1·0235 to nearly 1·0245; while in the south-western portion the density is below 1·0235, ranging usually down to 1·0220, and falling in the Gaspé Current itself to 1·0210. The dividing line between these two portions of the Gulf runs approximately from South-west Point, Anticosti, to a point in the middle of Cabot Strait. The densities in the border region near this dividing line naturally vary to some extent. The density of the north-eastern portion is practically the same as in the open Atlantic, as it was there found to range from 1·0237 to 1·0242, as shown by seven determinations made at the end of June off the south and south-east coasts of Nova Scotia.

This result is important in showing that the lower densities found in the south-western portion of the Gulf of St. Lawrence are confined to that side; and this also accords with the conclusion that the general set or drift across the Gulf is in the direction of a line from Gaspé to Cape Breton. On the other hand, the endeavour to obtain some differences locally, which would correspond with the various directions of the current, was without result; although a large number of temperatures as well as densities were taken for this purpose.

The deep water as found from samples taken at depths of 100

and 150 fathoms, both in the vicinity of Gaspé and in Cabot Strait, ranges in density from 1·0254 to 1·0261. The density of this deep water is very interesting in affording an explanation for the otherwise anomalous fact that the colder water at 50 fathoms is found to float upon it. It also corresponds with the density at similar depths, off the coast of Nova Scotia.

Current across the Gulf area.—The general connection of the Gaspé and Cape Breton currents became evident when it was ascertained that the water of lower density kept to the south-western side of the Gulf. The observations of the current in open, and the reports from steamships, also accord with a general movement of the water towards the south-east, as this is the more usual direction, and the currents which are found at times to run across this prevailing direction are to be attributed to the influence of the tides and the wind.

As to the route taken by the water in traversing the Gulf from the Gaspé region to Cape Breton, it seems fair to conclude, from the evidence furnished by the density observations, that the greater proportion finds its way eastward between the Magdalen Islands and Prince Edward Island, while a certain amount may also pass north of the Magdalen Islands, on the line from Bird Rocks to St. Paul Island. It is probable, also, that some of the water may come from Northumberland Strait, as the water there is also low in its density.

For a discussion of the probable reasons why the water of lower density keeps to the south-western side of the Gulf, the Reports of the Tidal Survey may be referred to.

The St. Lawrence River in relation to the outflow from the Gulf.—It can hardly be doubted that the low density of the water in the Gaspé Current is to be attributed to the outflow of the St. Lawrence River; and we are thus able to trace the influence of this water as far as Cape Breton, where it finally mingles with the water of the Ocean. The volume discharged by the St. Lawrence has been measured at different seasons, and with the addition of the principal tributaries along its estuary, the total volume of fresh-water discharge would probably amount in all to 340,000 cubic feet per second. This volume of fresh water will mingle with sea water for which we may assume a density of 1·0240, as this may be taken to represent either the mean density of Atlantic coast water to a moderate depth, or the density of the salter water in the Gulf itself. Under these conditions, the fresh water of the St. Lawrence would be sufficient to furnish a stream of water reduced to the lower density of 1·0230 which would be twelve miles wide and 68 feet deep, and moving with a speed of one knot per hour. This would represent the average density of the Gaspé Current, and would probably be an approximation to its average speed and its volume; and such a comparison may therefore serve to illustrate the way in which the conditions may be accounted for, if the data themselves were more closely known.

It is to be noted, however, that as regards volume the St. Lawrence River is almost insignificant as compared with the outflow of the Gaspé Current. This current, whether it flows near the coast or in the middle of the passage between Gaspé and Anticosti, has usually a width of about twelve miles. The total depth immediately off this coast is over 100 fathoms, and the depth or thickness of the current itself was ascertained from measurements of the under-current taken as far down as 30 fathoms, at times when the surface speed varied, as usual, between one and two knots. It results from these measurements that we may consider the volume of this current to be represented by a body of water 12 miles in width, with a mean depth of 30 fathoms, and moving with an average speed of 0·68 knot per hour, throughout this depth.

Such a current has a volume forty-three times greater than that of the St. Lawrence River. The volume of the Cape Breton Current, also, is probably much the same. These outflows must therefore be replaced by a return movement at the entrance to the Lower St. Lawrence, somewhere in the Anticosti region; and also by a return flow from the Ocean into the Gulf area, as the discharge of the St. Lawrence furnishes less than 3 per cent. of the amount required in either case.

The current which usually makes inwards around Cape Ray on the east side of Cabot Strait may be sufficient to compensate for the outflowing water of the Cape Breton Current; although it is also possible that the outflow from the Gulf may be partly made up for by the difference of flow in the inward direction through Belle Isle Strait, which in some years may be considerable in the early spring. This inflow at Cape Ray is in continuation of the general westward tendency of the water along the south coast of Newfoundland. The quiescence of the deep water in Cabot Strait is also to be noted in this connection.

It may be well to remark, however, that although the outflowing water of the Cape Breton Current is much warmer in the summer season than the incoming Atlantic water, it is not so at all seasons of the year. While it is probable that the total result is on the side of loss of temperature to the Gulf area, it would require extended observations throughout the year to ascertain the amount of loss and the probable effect, in consequence, upon climate in the surrounding regions.

The Current in Belle Isle Strait, in relation to the Gulf area as a whole.—On account of the tidal character of the current in Belle Isle Strait it is clear that no great volume of water can enter the Gulf of St. Lawrence from that quarter.

During the summer season the current flows in the Strait with a speed which is nearly equal in each direction; and there is only a difference in favour of inward flow to the west, which on the whole does not probably amount to more than a moderate percentage. From the discussion of all the evidence secured, it is perhaps possible that in the early spring the preponderance of inward flow may be proportionally greater than at other seasons. But no reasons have been found for supposing that this water passes completely round the west coast of Newfoundland and finds its way out into the Atlantic through Cabot Strait, between Cape North and Cape Ray, in accordance with the theory which has been more or less accepted up to the present time. All the indications are against this theory, as they show that any general current across the extent of the Gulf must lie in an entirely different direction. The reasons for this conclusion are discussed in the Tidal Survey Reports, in which the tidal character of the flow in this Strait is described and the relations of the current to the tide, the temperature of the water and the drift of icebergs are fully explained. A diagram showing the flow of the current in the two directions as observed is also given.

General Circulation in the Gulf.—In reviewing the movements of the water, with a view to tracing the general circulation in the Gulf, it is the principle of the balance of flow which is the most evident. Wherever a current of a constant character occurs, there is a corresponding return current to make up for it. Thus in Cabot Strait, the outflowing water in the Cape Breton Current is balanced by the inflow at Cape Ray; the north-eastward current on the west coast of Newfoundland is balanced by the contrary direction of the movement on the opposite shore; and we have fairly good indications of a return flow to compensate for the Gaspé Current.

It is this balance of flow which points to the nature and direction of the circulation of water in the Gulf. If we begin to trace it from Cabot Strait, where the balance between the Gulf and the Ocean takes place, the inflow at Cape Ray appears to diffuse itself more or less widely over the central part of the Gulf, but it regains its strength further north on the west coast of Newfoundland, and makes a deep bend into the north-eastern angle of the Gulf, and returns westward along the north shore. On reaching Cape Whittle it still makes westward; and, whether as an actual set or by displacing water which comes more directly from Cape Ray, it appears to work around the eastern end of Anticosti, and so compensates for the outflow of the Gaspé Current, from the estuary of the St. Lawrence. This current, after rounding the Gaspé coast, makes south-eastward as a general set or drift across the Gulf to the western side of Cabot Strait; and its waters there leave the Gulf in the outflow of the Cape Breton Current.

It also appears that the whole of the balance or compensation in the Gulf currents takes place at the surface and in ordinary under-currents, which do not probably extend to a greater depth than 50 or 60 fathoms at the most. There is nothing, therefore, to show the necessity for any appreciable movement in the deep water from 60 to 80 fathoms downward, which lies in the deep channels of the Gulf. Where direct observations have been obtained, this deep water appears to lie quiescent, without any movement that can be detected.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

PROF. T. HUDSON BEARE, professor of mechanical engineering at University College, London, has been appointed to the Chair of Engineering in the University of Edinburgh, in succession to the late Prof. Armstrong.